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The Production and Stock of College Graduates for U.S. States

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ABSTRACT

The stock of human capital in an area is important for regional economic growth and development. However, highly educated workers are often quite mobile, and there is a concern that public investments in college graduates may not benefit the state if the college graduates leave the state after finishing their education. This paper examines the relationship between the production of college graduates from a state and the stock of college graduates residing in the state using microdata from the decennial census and American Community Survey. The relationship is examined across states and across cohorts within states. The descriptive analysis suggests that the relationship between the production and stock of college graduates has increased over time and is nearly proportional in recent years. Instrumental variables methods are used to estimate causal effects. The preferred instrumental variables results yield an average point estimate for the production-stock relationship of 0.52, but the effect likely decreases with age.

JEL Codes: I25, J24, R23

Key Words: college graduates; human capital; migration; higher education policy

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Previous researchers have shown that the local stock of human capital is important for regional economic growth and development. College graduates, in particular, serve as engines of growth to create more and better jobs and increase the earnings and employment rates of their neighbors (Abel, Dey, and Gabe 2012; Glaeser and Resseger 2010; Moretti 2004; Rauch 1993; Winters 2013). Highly educated workers are thought to increase local productivity for others through knowledge spillovers, location-specific production innovations, complementarities in production, and increased demand for locally produced goods and services (Glaeser and Saiz 2004; Moretti 2004; Winters 2013). Educated workers are also thought to make their areas more desirable places to live and increase the local quality of life by supporting cultural amenities, improving governance, and increasing tolerance (Shapiro 2006; Winters 2011a). As such, the local stock of college graduates has been found to increase future population and employment growth (Glaeser and Saiz 2004; Simon 1998; Simon and Nardinelli 2002).

Because of the societal benefits of human capital, researchers and policymakers are interested in how regions can grow their stock of highly educated workers. One approach is to implement policies intended to increase college graduation rates among the region's young people, for example, by lowering the costs of college, increasing geographic access, or increasing college preparation via improved primary and secondary education. In the United States, states are the predominant providers of higher education. Each of the 50 states has its own higher education system, and 63.0 percent of bachelor's degrees conferred in 2012 were obtained from public institutions receiving state government support (Snyder and Dillow 2015). Similarly, primary and secondary education are critical prerequisites for higher education, and states play major roles in their provision with state government revenues accounting for 44.1 percent of total K–12 revenues in 2011 and local governments accounting for another 43.4 percent (Snyder and

Dillow 2015). States subsidize education in part because of the benefits to the state of having an educated population.

However, college graduates are especially mobile and often leave their home states after graduation. Those who do leave take the bulk of the external benefits of their human capital with them to their new homes. A state's investments in graduates who leave that state to work in another area may not provide sufficient benefits to the investing state to justify the costs. In other words, external benefits to a state from additional college graduates largely depend on their ability to keep them within their jurisdiction. If states cannot internalize these externalities, subsidizing college graduate production does not achieve the desired outcomes. Thus, many researchers and policymakers are concerned that state investments in education may not be well spent from the state's perspective (Bound et al. 2004).

This paper helps assess the benefits of educational investments to a state by investigating the relationship between the production and stock of college graduates for states, which depend critically on migration decisions. More specifically, the paper assesses the extent to which increased production of college graduates among a state's young people increases the later stock of college graduates residing in the state. The stronger the production-stock relationship for college graduates, the greater the benefits of state investments in education. However, a very weak production-stock relationship due to high levels of out-migration would cast doubts on the efficacy of educational investments for states.

This paper uses decennial census and American Community Survey (ACS) microdata to measure both the production and stock of college graduates across and within states. The data report both the state in which an individual currently resides and the state in which they were born. However, the data do not report where individuals completed education or when outmigrants left their birth state. Similar to Bound et al. (2004), the stock of college graduates in a state at a given point in time is measured by the percentage of the state's residents of a given age at the time of the survey whose highest education is a bachelor's degree or higher. However, unlike Bound et al. (2004), this paper measures the production of college graduates by the percentage of persons of a given age *born* in a state who have earned at least a bachelor's degree by the time of the survey, unconditional on where they earned their degree or currently reside. The stock of college graduates in a state is then regressed on the production from the state, first looking at cross-sectional differences across states and then looking at differences across cohorts within states using state fixed effects.

Examining the production-stock relationship by measuring the production of college graduates based on individuals' birth states provides new insights to the literature on state human capital creation. Obviously, not everyone born in a state who earns a college degree does so in their native state and many young people leave their birth state even before entering college. However, the majority of young people continue to reside in their birth state. For example, in the 2012 ACS 71.8 percent of college enrollees aged 18–22 resided in their state of birth at the time of the survey.[1] Furthermore, 81 percent of persons age 17 in the 2012 ACS resided in their birth state. Thus, measuring the production of college graduates among persons born in a state can provide useful insights, but care must be taken in interpreting the results as discussed below.

An important empirical concern is that both the production and stock of college graduates may be driven by economic conditions in the state that increase the demand for college-educated labor. If so, OLS regression coefficients that fail to account for economic conditions may suffer from omitted variable bias. The analysis accounts for this concern in two ways. First, time-

[1] Notably, the percentage of college enrollees enrolled in their birth state does vary across states and somewhat across cohorts within states. This has the potential to affect post-college location decisions as suggested by Sjoquist and Winters (2014).

varying state controls measured at the time an individual is age 18 are included, such as the wage premium for college graduates relative to high school graduates, the unemployment rate, median household income, cohort size, and a state merit aid program variable. Second, instrumental variables (IV) are used to obtain exogenous variation in the percentage of persons from the state who graduate from college. The preferred instrument uses lagged decennial census data to compute the average education levels of mothers of children of a given birth cohort. The birth cohort maternal education levels are matched to respondents of future ACS surveys. Thus, past increases in maternal education are used to predict future increases in the education levels of young adults.

Previewing the results, this paper consistently finds a significantly positive relationship between the production of college graduates from a state and the stock of college graduates in the state. The descriptive analysis suggests that the cross-sectional bivariate relationship has increased over time and is nearly proportional in recent years, especially for younger persons. The preferred IV results yield an average point estimate for the production-stock relationship of 0.52, though the effect likely decreases with age. These results have important implications for states and provide insights into how human capital investments affect regional economies. The positive production-stock relationship suggests that states can benefit from public investments that increase college completion rates among state natives. While some graduates will leave the state after completing their education, many will stay and help build the stock of college graduates in the state.

PREVIOUS LITERATURE

A sizable literature has explored the various determinants and consequences of the migration decisions of both college graduates and non-graduates for the U.S. (Betz, Partridge, and Fallah 2015; Chen and Rosenthal 2008; Faggian and Franklin 2014; Ferguson et al. 2007; Hawley and Rork 2013; Leguizamon and Hammond 2015; McHenry 2014; Partridge 2010; Partridge et al. 2010; Whisler et al. 2008; Winters 2011b; Scott 2010; Zheng 2015) and other countries (Abreu, Faggian, and McCann 2015; Brown and Scott 2012; Carree and Kronenberg 2014; Corcoran, Faggian, and McCann 2010; Di Cintio and Grassi 2013; Faggian, McCann, and Sheppard 2007a,b; Faggian, Corcoran, and McCann 2013; Haapanen and Tervo 2012; Hansen and Niedomysl 2009; Liu and Shen 2014; Marinelli 2013; Miguélez and Moreno 2014; Venhorst 2013).[2] These studies collectively find that numerous individual and geographic characteristics have important effects on location decisions; see Faggian et al. (2015) for a review. Important geographic factors affecting location decisions include employment and earning opportunities, natural and man-made amenities, and social networks. Individual characteristics such as age, gender, marital status, and education both affect migration directly and affect the relative importance of various geographic characteristics in individual location decisions.[3] Furthermore, mobility rates differ across countries and regions, as do the importance of various factors affecting location decisions.

[2] Special issues on graduate migration were published in 2014 in both *Regional Studies* (Issue 10) and *Spatial Economic Analysis* (Issue 4).

[3] Of particular importance, higher education appears to increase one's propensity to migrate (Malamud and Wozniak 2012; Haapanen and Böckerman 2013). Machin, Salvanes, and Pelkonen (2012) also find evidence that changes in compulsory schooling laws in Norway increased secondary education and as a result also increased internal migration rates. McHenry (2013), however, finds that increases in secondary education due to compulsory schooling laws in the United States actually reduce out-migration. There are, of course, considerable differences between the United States and Norway and between secondary and higher education, and the conflicting results are not very surprising.

A small strand of the migration literature has examined the empirical relationship between the production and stock of college graduates. Bound et al. (2004) examine how increased production of college graduates *in* a state affects the later stock of college graduates residing in the state years later. They compute bachelor's degree production rates from the Integrated Postsecondary Education Data System (IPEDS) and match them to college educated stock rates in the 1960–1990 decennial censuses.[4] Their baseline specification for 1990 suggests that a 1 percentage point increase in the production of college graduates in a state only increases the stock of college graduates in the state by about 0.3 percentage points. This modest coefficient suggests that the majority of the benefits from educating more graduates during their period of analysis accrued to other states because the additional graduates were very likely to leave the state in which they were educated. Of course, the dynamics of student and college graduate migration could change over time.

Two additional studies also use the IPEDS to examine the production-stock relationship for college graduates. Trostel (2010) combines IPEDS data with the 1992–2005 Current Population Survey (CPS) and finds the production-stock relationship to be nearly proportional. Abel and Deitz (2012) use the IPEDS with 2000 Census and 2006 ACS data to examine the production-stock relationship for college graduates within metropolitan areas. They find a small positive relationship. However, many metropolitan areas are too small and specialized to absorb even most of the human capital that they create, and this is especially true for relatively small college town metropolitan areas. Thus, the production-stock relationship for metro areas likely differs from that for states, which is typically larger.

[4] One limitation with the IPEDS data is that it does not report the age of graduates, which can create some measurement error when assigning graduates from graduation years to cohort years. Bound et al. (2004) conduct a measurement error simulation exercise and conclude that measurement error likely only minimally affects their results.

The current paper contributes to the literature on college graduate location decisions by examining the relationship between the production and stock of college graduates across states. This study measures the production of college graduates *from* a state by the percentage of persons of a given age cohort born in a state who have earned at least a bachelor's degree by the time of the survey; this measure includes all college graduates born in the state regardless of where they earned their degree. To the author's knowledge, this is the first study to examine the production-stock relationship for college graduates across states in this way. This approach provides new insights to an important field of research, albeit to a different question than that addressed by previous researchers measuring college graduate production using IPEDS data. IPEDS data measure the production of college graduates *in* a state regardless of where they are from.[5] This paper examines the effects of increasing the production of college graduates among persons *from* a state unconditional on where they complete their degree or later reside. This analysis can help understand the efficacy of state policies intended to increase college attainment among a state's young people.

CONCEPTUAL FRAMEWORK

College graduates must decide whether to remain in the area where they earned their degree, move back to a previous area, or move on to a new one. The human capital model suggests that graduate migration decisions depend on the costs and benefits of locating in various areas (Sjaastad 1962). Individuals make location choices that maximize their own expected

[5] The production of college graduates *in* a state using IPEDS data is based on the location of the college or university and not the origin location of the individuals receiving the education. IPEDS data therefore, includes both persons from that state and persons originally from other states or nations. Thus, IPEDS production *in* a state can change for various reasons including educating more non-residents *in* the state, many of whom are likely to have weak attachments to their non-resident state and move on to a new area after finishing their degree.

utility. However, the utility-maximizing location will vary across individuals because of different preferences, skills, and experiences. Thus, for a given area, some graduates will stay and some will leave. Furthermore, most regions in developed countries will receive at least some in-migration of college graduates from other areas.

States may be able to increase their stock of college graduates by increasing public investments in education.[6] Increasing the production of college graduates, however, may not translate into an increase in the stock of college graduates because of out-migration. If there were no migration (or mortality), a 1 percentage point increase in college graduate production for a given cohort in a state would lead to a 1 percentage point increase in the college graduate stock of that cohort in the state. However, because migration is possible, the production-stock relationship may not be proportional. In fact, if individuals were perfectly geographically mobile such that later life location decisions were independent of earlier ones, the correlation between the production and stock of graduates would be zero. In reality, there are moving costs, and individuals are not perfectly mobile across areas. Many individuals have attachments to family, friends, and other local attributes that often make them reluctant to move.[7] Forces inhibiting individual migration will induce a positive relationship between the production and stock of graduates, but the relationship is not necessarily one-to-one and could be quite small. The relationship between the production and stock of college graduates is ultimately an empirical question.

[6] This paper uses states as the unit of analysis because of the primary role played by state government entities in the production of education in the United States. Alternative regional units such as metropolitan areas do not directly correspond to governmental entities with the ability to affect the production of college graduates.

[7] Winters (2011b) suggests that the relationship between metropolitan human capital levels and future population growth is largely driven by students moving to an area for college and then staying in the area after finishing their education. He postulates that some students stay because of attachments they make while in college.

Individuals deciding whether or not to attend and complete college weight the costs and benefits of doing so. The benefits include higher expected future earnings and improved future health (Buckles et al. 2013; Card 1999; Hoogerheide, Block, and Thurik 2012; Winters 2015). The costs include tuition and fees, the opportunity costs of time including forgone earnings, and the financial and emotional costs of leaving home for young people without good higher education options near their parental residence (Card 1999). A young person will choose to participate in higher education if the expected benefits exceed the expected costs. Of course, the benefits and costs from education that individuals face will depend on individual endowments and preferences, so that some young people will complete college and others will not.

Many young people are at the margin of whether or not to complete college, and policymakers may be able to take actions that encourage these young people to complete college. For example, tuition and financial aid policies for state residents at the state's public colleges and universities might affect individual's educational decisions. Specifically, increasing state subsidies to lower the net costs of college for residents would likely encourage young people making marginal educational decisions to complete college.[8] According to the law of demand, a reduction in the net price students pay should increase their participation in higher education (Leslie and Brinkman 1987). Other investments in higher education could involve creating new colleges and universities to increase access in areas that are long distances from affordable higher education institutions; increasing geographic access has been shown to improve higher education outcomes (Alm and Winters 2009; Böckerman and Haapanen 2013; Sá, Florax, and Rietveld 2006). Or higher education investments could be targeted to providing student support

[8] Alternatively, states could direct more resources toward improving the quality of higher education in their state, which might affect where students choose to enroll (Ciriaci 2014). However, students at the margin of attending college or not may not be much affected by marginal improvements in quality. Similarly, marketing and recruiting efforts by states, universities, foundations, and alumni may have some potential to affect whether young people attend college but are more likely to affect where they do.

services, tutoring programs, smaller class sizes, and increased course availability (Card and Lemieux 2001; Bound, Lovenheim, and Turner 2010; Bound and Turner 2007; Tinto 2010). Alternatively, some observers suggest that inadequate college preparation may be an especially important barrier to college completion for many students. This suggests that increased state investments that improve primary and secondary education may be an effective way for many states to increase college completion rates among their young people.[9]

This paper's college graduate production measure captures increased production among young persons *from* a state regardless of where they earn their degree. This measure is not directly linked to any specific higher education policy. Instead, it is most closely related with broad policy goals of increasing college attainment among a state's young people. The magnitude of the production-stock relationship estimated in this study can help policymakers assess the benefits of increasing college attainment among their state's young people. The stronger is the production-stock relationship for college graduates, the greater are the benefits of increasing college graduation rates among the state's young people.

DATA AND EMPIRICAL APPROACH

The data for this paper come primarily from the decennial census and the American Community Survey (ACS) and were accessed from IPUMS (Ruggles et al. 2010). The paper first presents some descriptive analysis that examines the cross-sectional bivariate relationship between the production and stock of college graduates across states using the decennial census

[9] Interestingly, improved primary and secondary education that increases college preparation has the potential to increase college enrollment among the state's residents at higher education institutions both in the state and outside the state. As noted, the college production measure in this study captures whether young people complete college, not where they do so.

for 1960-2000 and using the ACS for 2006 and 2012. More specifically, several Ordinary Least Squares (OLS) regressions are estimated with the form:

$$(1) \qquad Stock_{sta} = \alpha + \beta_{ta} Production_{sta} + \varepsilon_{sta}$$

The stock of college graduates in state s in year t for age group a is measured by the percentage of state residents of that age at the time of the survey who have completed at least a bachelor's degree. The production of college graduates from state s by year t for age group a is measured by the percentage of persons in that age group born in the state who have earned at least a bachelor's degree by the time of the survey. Prior to the 1990 census, the U.S. Census Bureau asked respondents to report their education level based on the number of years of schooling instead of explicitly reporting college degrees earned. For 1960–1980, an individual is considered to be a college graduate if they had completed at least four years of college, which may induce some degree of measurement error because some people may have completed a bachelor's degree in less than four years and some may have completed four years of college without earning a degree. Beginning in 1990, respondents were asked to report the highest degree completed, and researchers can precisely and directly identify persons who have completed at least a bachelor's degree. See Ruggles et al. (2010) for more details and exact questionnaire wording. The initial sample is restricted to persons aged 25–59. The production-stock relationship is examined for the full 25–59 age range and separately for five-year age groups.[10] The β coefficient is also allowed to vary over time.

The bivariate cross-sectional relationship between the production and stock of college graduates across states is intended to be descriptive and not necessarily causal. Both the production and stock of college graduates may be driven by economic conditions in the state that

[10] Regression results reported in this paper are estimated using state-year-age cohort sizes as weights. Unweighted regressions are qualitatively similar.

increase the demand for college-educated labor. If so, OLS regression coefficients of Equation (1) will not represent a causal relationship. The cross-sectional analysis is next modified by pooling the 2006–2012 ACS and estimating:

(2) $$Stock_{stac} = \alpha + \beta Production_{stac} + \gamma StateControls_{stac} + \delta_s + \theta_t + \pi_a + \varphi_c + \varepsilon_{stac} \text{ ,}$$

where *s*, *t*, and *a* again index state, survey year, and age at the time of the survey, and *c* now indexes year-of-birth cohort, where year-of-birth is computed as the survey year minus age at the time of the survey. State fixed effects (δ_s) control for persistent differences across states in human capital levels. Identification then comes from differences across cohorts within states. The regression also includes dummy variables for survey year (θ_t), age (π_a), and year of birth (φ_c); since these last three are somewhat redundant, perfectly collinear variables are dropped. The regression also includes a set of cohort-varying state controls, which are discussed further below.

The primary hypothesis being tested for both Equations (1) and (2) is whether there is a relationship between the production of college graduates and the stock of college graduates that is statistically distinguishable from zero. The null hypothesis is that there is zero relationship between the two. The expectation is that there will be a significant positive production-stock relationship, but there is some skepticism about this likelihood. A secondary hypothesis considered is whether the production-stock coefficient is statistically less than one; expectations for this hypothesis are much less clear but the hypothesis has considerable interest and importance. Finally, differences in the production-stock coefficient by age and over time are also hypothesized and examined. Specifically, the production-stock coefficient is expected to decline with age; expectations for differences over time are largely unclear, but certainly of interest.

Estimating Equation (2) could still produce biased and inconsistent estimates of β for two main reasons. First, there may still be unobserved cohort-specific factors within states that are correlated with both the production and stock of college graduates. Second, the production of college graduates is likely measured with some degree of error due to sampling. Each year of the 2006-12 ACS includes a one percent sample of the population. States are sufficiently large that these samples will typically produce fairly precise estimates of the true population characteristics, but problems with measurement error are greatly exacerbated when variables are measured by single year of age and controlling for state fixed effects and the other variables. Classical measurement error will attenuate coefficients toward zero.

An IV strategy is used to account for both potential sources of bias discussed above. More specifically, 1980 and 1990 decennial census microdata are used to compute maternal education levels for children by state and birth cohort. The birth cohort maternal education levels are then matched to young adults in the 2006-12 ACS based on state of birth and year of birth. Thus, past increases in maternal education are used to predict future increases in education levels for the next generation. The motivation for the instrument used comes from the literature on the intergenerational transmission of education (Behrman and Rosenzweig 2002; Björklund and Salvanes 2011; Black, Devereux, and Salvanes 2005; Chevalier et al. 2013). This literature generally finds that maternal education is strongly positively correlated with later child education outcomes.[11] Maternal education has been used as an instrument for education at the individual level (see Card [1999] and Hoogerheide, Block, and Thurik 2012), but the author is unaware of

[11] One could also consider using an instrument based on paternal education, but a much higher percentage of children have no father figure present in the household, so paternal education is likely a less reliable instrument.

any other researchers using cohort-level maternal education as an instrument for cohort-level education levels.[12]

There are some issues with the maternal education IV strategy. First, the questionnaire does not directly ask survey participants to report their mother's education. Instead, it can be computed indirectly for persons living in the same housing unit as their mother based on the mother's reported education. This means one cannot observe maternal education for most adults because most persons finish high school around age 18 and then often move out of their parents' homes to go to college or establish their own residences, and persons who reside with their parents after age 18 are likely to differ in their eventual education levels from persons who have already left. Specifically, only 8.3 percent of persons aged 25–59 in the 2012 ACS lived with their mother; the percentage of college graduates was 22.7 for persons living with their mother and 31.8 for persons not living with their mother. Thus, one cannot use census/ACS data to credibly compute maternal education levels for adults.

Instead, this study computes maternal education levels for children age 17 and younger at the time of the 1980 and 1990 census surveys (based on April 1 of the census year). Fortunately, 93 percent of these children live with a biological mother, adoptive mother, or stepmother, so cohort-level maternal education levels can be reasonably accurately estimated. To construct the instrument, this study treats all "mothers" living with their children the same, i.e., it does not differentiate between biological mothers, stepmothers, and adoptive mothers who live in the same residence as their child. However, children who live with no mother, stepmother, or adoptive mother must be excluded in computing the instrument.[13] These issues will introduce

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[12] Winters (2015) uses cohort-level maternal education as an instrument to estimate the wage returns to years of schooling.

[13] One could also consider excluding children who live with a stepmother or adoptive mother, but this could meaningfully alter the composition of children included in the measure and weaken both the power and

some measurement error in the instrument, but this measurement error is plausibly random at the state-cohort level and fairly minimal. The two-stage least squares (2SLS) procedure used herein can account for random measurement error in the instrument so long as the measurement error is not severe. For those with maternal education reported, this study computes the percentage of the state-of-birth and year-of-birth cohort whose mother had completed a bachelor's degree or higher and use this for the instrument. One could also consider computing mean maternal years of schooling, but since the instrument is for the production of college graduates, maternal education levels should likely be focused on college graduates also.

The 2SLS regression analysis below matches maternal education levels from the 1980 and 1990 census 5 percent PUMS to adults aged 25–49 in the 2006–2012 ACS who were born between 1963 and 1987.[14] Earlier years of the ACS are excluded because they do not include the group quarters population, though including them does not substantially alter the results. Persons older than age 49 in 2006–2012 were born before 1963. Persons born before 1963 were older than 17 in 1980 and lack reliable maternal education levels.[15] Persons born after 1987 had not reached age 25 by 2012.

validity of the instrument. Furthermore, even if one thinks that biological mothers are the most relevant group of mothers, they are not observed for many children and arguably the best available way to impute their biological mother's education is based on their nonbiological mother's education. Finally, the analysis uses a cohort level measure of maternal education, so individual "mismeasurement" in maternal education from stepmothers and adoptive mothers is likely to average out to some extent if biological mothers and coresidential stepmothers and adoptive mothers have similar education levels.

[14] A few cohorts were under age 18 in both 1980 and 1990, i.e., those born 1973–1980. Maternal education levels for these cohorts are measured based on the 1990 census, in part because the education measure was better in 1990 than in 1980 as noted above. Thus, the 1963–1972 birth cohorts have maternal education from the 1980 census, and the 1973–1987 cohorts have maternal education from the 1990 census. Using the 1980 census maternal education instead for the overlapping years produces nearly identical results.

[15] The 1970 census could be used to estimate maternal education levels for older cohorts, but the current study does not do so in order to focus on persons in age ranges with stronger attachments to the labor force. Furthermore, maternal college graduation rates were also much lower in 1970 and the available samples are only 1 percent instead of 5 percent of the population, so using 1970 maternal education would likely weaken the instrument.

A valid instrument should be both relevant and exogenous. The relevance assumption requires that the instrument have a strong statistically significant effect on the potentially endogenous explanatory variable in the first stage of a 2SLS regression. The exogeneity assumption requires that the instrument be uncorrelated with the error term in the second stage equation, that is, the instrument should only be correlated with the dependent variable through its effect on the potentially endogenous variable for which it is being used as an instrument. One can test the relevance assumption, and evidence on this is provided below, but one cannot test the exogeneity assumption for only one instrument. Conceptually, however, cohort-level maternal education seems a plausible instrument in this setting. First, computing the instrument using the 1980 and 1990 censuses and first observing the dependent variable at least 16 years later reduces concerns that maternal education might somehow be affected by contemporaneous labor market conditions that also increase the education level of state residents. More importantly, including state and year-of-birth fixed effects controls for unobserved state effects and unobserved time effects. Identification comes from variation in maternal education across cohorts within birth states. This variation is likely due to largely random factors such as state higher education policies and changing expectations about female education, labor force participation, and fertility that affected states differently at different times.

Equation (2) also contains a set of cohort-varying state control variables for the cohort sex, race, and ethnicity distributions via separate variables for the percentage of cohort c born in state s observed in survey year t who are female, black, Asian, Hispanic, and other nonwhite. It also includes additional cohort-varying state of birth control variables measured at the time an individual is age 18; these include the college wage premium, the unemployment rate, the log of median household income, the log of the cohort size, and a dummy for whether the state of birth had adopted a state merit scholarship plan by the time the cohort was age 18.[16] The college wage premium and log median household income are computed from the March Current Population Survey (CPS). The college wage premium is measured as the log wage premium in the state between persons with only a high school diploma and persons with only a bachelor's degree for full-time (35+ hours per week) and full-year (35+ weeks per year) workers aged 25–54. The unemployment rate is obtained from the Bureau of Labor Statistics (BLS). Cohort size data are obtained from the Census Bureau's intercensal population estimates. The merit aid dummy variable is from Sjoquist and Winters (2014, 2015). They report that 27 states adopted some form of a state merit aid program between 1990 and 2005, though they primarily focus on nine states with especially large programs. Sjoquist and Winters (2014, 2015) find that these merit programs had no effect on an individual's educational attainment, but they did make them on average more likely to reside in their birth state post-college.[17]

EMPIRICAL RESULTS

Bivariate Cross-Sectional Relationship between the Production and Stock

Table 1 illustrates the bivariate cross-sectional relationship between the production and stock of college graduates across states in the 2012 ACS. It lists each of the 50 states, the college share for each state by birth and by residence, and the state's college share rank by birth and residence, with the most educated state ranked first and the least educated ranked 50th. The college shares report the percentage of persons aged 25–59 who have at least a bachelor's degree. The college share by state of birth ranges from a high of 41.0 percent in Connecticut to a

[16] Results below are robust to also including controls for these state characteristics at age 22.

[17] The dummy is equal to zero for all states not adopting merit aid. For merit adopting states, the dummy equals zero for cohorts age 18 before the program was implemented and one for cohorts age 18 after the merit program was implemented. A single dummy is used for all merit aid programs, but results below are qualitatively robust to using separate dummies for strong and weak merit states as defined in Sjoquist and Winters (2014, 2015).

low of 23.6 percent in West Virginia. The college share by state of residence ranges from a high of 42.9 percent in Massachusetts to a low of 20.0 percent in West Virginia. There are some moderate exceptions, but overall the two college share measures are quite similar for most states. Massachusetts and Connecticut are the top two in both measures and Mississippi and West Virginia are the bottom two in both measures. The correlation coefficient between the college share by state of birth and state of residence is 0.795; the Spearman rank correlation coefficient is 0.808. Overall, states that produce a high percentage of college graduates tend to have a large stock of college graduates in residence.

Table 2 reports regressions results for Equation (1) estimated separately for different age ranges and survey years. Specifically, the age range first includes all persons aged 25–59 and then separately examines five-year age ranges within the 25–59 group. The relationships are estimated for each of the 1960–2000 decennial censuses and the 2006 and 2012 ACS. The bivariate production-stock coefficient is statistically different from zero for all age groups in all years considered. However, the coefficient magnitudes do vary somewhat across ages and years. In 1960, the coefficient for those aged 25–59 was only 0.493, suggesting that a 1 percentage point increase in the college share among persons born in the state is associated with an increase in the college share among persons residing in the state by 0.49 percentage points. This positive coefficient is statistically different from one. The production-stock coefficient for ages 25–59 grows steadily over time and by 2012 the coefficient is 0.847 and is not statistically different from one at the 5 percent level of significance. Thus, by 2012 the cross-sectional relationship between the production and stock of college graduates aged 25–59 across states is such that a 1 percentage point increase in the share of college graduates from a state is associated with a nearly 1 percentage point increase in the share of college graduates residing in the state.

The coefficient estimates for five-year age groups also increase over time and by 2012, the coefficient estimates are not statistically different from one for ages 25–29 and 30–34. The coefficients also generally decrease by age. For 2012 the production-stock coefficient for persons aged 55–59 is “only” 0.606, which is a good bit less than one. The coefficient is likely smallest for the oldest age group examined primarily because an individual’s likelihood of living in their state of birth declines as they age. Each year some members of a cohort leave, and while some move back, the net cumulative effect is an increasing outflow over time. This suggests that the relationship between the production and stock of college graduates should decline with age.

While the relationships characterized in Table 2 are descriptive, the fact that the production-stock coefficient has increased so substantially over time likely has important but not fully understood implications. First, one might wonder whether this trend will continue into the future and if so by how much. Will the coefficients ever significantly exceed one? What is driving the increase? At least a couple of factors may have a plausible role in the increase over time. First, migration rates have declined significantly in recent years (Molloy, Smith, and Wozniak 2011; Partridge et al. 2012). As people become less mobile and migration rates decline over time, the characteristics of a state’s residents will begin to look more like the characteristics of the state’s natives. This is true for education, but also for other characteristics. A second yet quite different explanation is that high human capital workers may be becoming increasingly complementary with other high human capital workers causing them to cluster in specific areas and average human capital levels to diverge across space, as suggested by Berry and Glaeser (2005), Moretti (2013), Fratesi and Percoco (2014), and Lindley and Machin (2014). The analysis here is unable to shed much light on how important these factors are for explaining the increased production-stock coefficient over time, but this increase is an important empirical finding in need of future research.

OLS Effects across Cohorts within States

Table 3 presents OLS results for Equation (2) in which the variables are now measured by survey year and single year of age. Standard errors are clustered by state in order to account for possible serial correlation across cohorts within states. The sample is the 2006–2012 ACS cohorts aged 25–49 who were born between 1963 and 1987, the same restrictions as when using the maternal education instrument to increase comparability of the results. The first column of Table 3 reports the regression coefficient with no controls. The second column adds age, survey year, and year-of-birth dummies; the third adds state fixed effects; and the fourth adds the time-varying state controls.[18]

Columns 1 and 2 without the state fixed effects report similar coefficients of 0.827 and 0.815, respectively, that are statistically different from both zero and one at the one percent level of significance. These coefficients are also quite comparable to the results in Table 2 for 2006 and 2012. Adding the state fixed effects, however, reduces the coefficient to 0.521 in column 3. Adding the time-varying state controls further reduces the coefficient to 0.477 in the fourth column. The results seem to suggest that much of the cross-sectional relationship between the production and stock of college graduates is driven by time-invariant state-specific unobserved factors. However, the decrease could also be attributable to measurement error bias that is

[18] For brevity the coefficient estimates for the age, year, year-of-birth, and state dummy variables are not reported. These variables are jointly significant in all models. This is consistent with expectations of differences in human capital levels across states (similarly to illustrations in Table 1) and expectations that college graduation rates differ by age and over time.

exacerbated by the state fixed effects.[19] The IV approach below will account for measurement error and other sources of bias.

2SLS Estimates Using Maternal Education as an Instrument

Table 4 presents results for Equation (2) that instrument for the production of college graduates from a state for a given age cohort using the maternal education instrument. More specifically, the instrument is the percentage of a birth cohort whose mother has at least a bachelor's degree in the 1980 or 1990 census. The sample is the 2006–2012 ACS cohorts aged 25–49 who were born between 1963 and 1987. Table 4 follows the structure of Table 3, with four columns that add progressively more control variables. Standard errors are clustered by state. The upper panel of Table 4 presents the first-stage results for the excluded instrument, and the lower panel reports the 2SLS results for the birth state college share production variable. For all four columns of Table 4, the first stage coefficients for the excluded instrument are highly significant and the F-Statistics are well above 10, which satisfies a rule of thumb suggested by Stock, Wright, and Yogo (2002) and Angrist and Pischke (2009) to test for weak instruments. An F-statistic greater than 10 suggests that weak instrument bias is likely to be very minimal.

The second-stage coefficients for the birth state college share in Table 4 are all positive and statistically different from zero at least at the 5 percent level. The coefficients for the first two columns are 1.033 and 1.107, respectively, and neither is statistically significantly different from one. Adding state fixed effects reduces the coefficient to 0.870 in the third column, but it is still not significantly different from one. However, adding the time-varying state controls lowers the coefficient to 0.522, and it is significantly less than one at the five percent level. The results

[19] Classical measurement error attenuates OLS coefficient estimates toward zero because only some of the observed variation in the data is due to true variation in the population (signal) and the rest is due to measurement error (noise). As one includes controls such as state fixed effects that are strongly correlated with the true signal, the proportion of the observed variation attributable to the noise increases, exacerbating measurement error bias (Wooldridge 2010, pp. 365–368).

confirm that controlling for state fixed effects and time-varying state characteristics are important, even when using IV.[20]

The results in the fourth column of Table 4 are the preferred estimates. The significant coefficient of 0.522 confirms that increased production of college graduates from a state does have an economically meaningful effect on the stock of college graduates residing in the state. However, the effect is much less than proportional. The results suggest that increasing college graduation rates of a state's natives by 1 percentage point will increase the percentage of the state resident's with a college degree by 0.52 percentage points.

Separate 2SLS Estimates for Ages 25–35 and 36–49

The descriptive analysis in Table 2 suggests that the production-stock relationship might differ by age. The sample is next divided into two age groups, 25–35 and 36–49, and separate 2SLS regressions are estimated for the two age groups.[21] Other sample restrictions correspond to those in Table 4. Results are reported in Table 5 using maternal education as an instrument and include the full set of controls. The instrument is significant in the first stage for both age groups with F-Statistics exceeding 10.

The second-stage coefficients are both positive and statistically significantly different from zero. However, the coefficient magnitude appears to vary between the two age groups. For persons aged 25–35 in column 1, the production-stock coefficients is 0.75 and is not significantly

[20] In results not shown, additional control variables were explored for time-varying state characteristics including two variables from the 1980/1990 census and one from the March CPS for the year the cohort was age 18. The two census variables were the percentage of a cohort living without a mother in the household and the percentage of the cohort whose mother resided outside her state of birth. The CPS variable measured the percentage of adult workers in the state employed in industries classified by IPUMS as Professional and Related Services, Finance, Insurance, and Real Estate, or Public Administration. Including these additional variables minimally affects the results. The coefficient for the full maternal education IV specification goes from 0.522 to 0.545, but the difference is not statistically significant.

[21] Splitting the sample based on these ages divides the sample using the maternal education instrument exactly in half. Results are qualitatively robust to moderate changes in the age ranges considered.

different from one. However, for ages 35–49 in column 2, the production-stock coefficient is only 0.366 and is significantly different from one. This suggests that the relationship between the production and stock of college graduates decreases with age as suggested in Table 2. However, it is worth noting that Table 2 also suggests that there may be generational effects with younger generations being less mobile in general. Generational differences could explain the results in Table 5 as well.

Additional Results

As a robustness check, a second IV strategy was implemented that was primarily intended to account for bias due to measurement error. This alternative IV strategy instruments for the production of college graduates from state s and cohort c observed in survey year t using the production of college graduates from state s and cohort c observed in survey year $t-1$. That is, the college share from a state of birth for a given cohort is instrumented using the one survey year lag for that cohort. If the measurement error is solely due to sampling and independent across years, this IV approach will eliminate any bias from measurement error. However, it will not address concerns about bias from omitted variables correlated with both the production and stock.

Results for this procedure are presented in Appendix Table A.1, which follows the same structure as Tables 3 and 4.[22] The instrument is significant in the first stage for all specifications with F-Statistics exceeding 10. The results with the full set of controls give a production-stock of coefficient of 0.638, which is not statistically different from that obtained using the maternal

[22] The sample is now the 2007–2012 ACS cohorts aged 25–49 who were born between 1963 and 1987. The 2006 ACS observation are now dropped from the second stage in order to not use the 2005 ACS in the instrument since persons in group quarters are excluded in that year. From a practical standpoint, the results are qualitatively robust to including the 2006 cohorts and using the 2005 ACS for the instrument. To avoid losing further observations, the college share at age 24 is used in the instrument in order to include persons age 25 in the second stage.

education instrument. Appendix Table A.2 reports results estimating Equation (2) jointly using both instruments; the second-stage coefficient estimate with the full controls is 0.557. Appendix Table A.3 presents additional results by age group using the one-year lag instrument and both instruments. However, the preferred results in this paper continue to be those that use only the maternal education instrument.

IMPLICATIONS AND SUGGESTIONS FOR FUTURE RESEARCH

The results in this paper have important implications. Previous literature suggests that college graduates are very important to state economies and create a number of external benefits that accrue to the state in which they reside. The results suggest that when states produce more college graduates, they absorb more college graduates as well. While many college graduates will leave their home state after finishing their education, many others will stay, at least for some time, and help build the stock of human capital in the state. The production-stock relationship estimated in this study is less than proportional, but the magnitude may be sufficiently large to justify public policies intended to increase college graduate rates among a state's young people.

However, the less than proportional production-stock relationship also has implications for federal government policies. When a state invests in a young person's education and then loses the young person to another state, the external benefits from that person's education accrue to the receiving state. Thus, individual states are unable to fully internalize the benefits of their educational investments and have some incentive to invest less than the socially optimal amount if not compensated for the external benefits they create. Federal government policies could attempt to correct for this market failure of underinvestment of education in two ways. First, they could track graduates across states and create some form of compensation system for the external benefits that one state receives from another. However, the complexity involved and potential for adverse incentives may make this desirable. Instead, the federal government can and does take on some of the responsibility for financing education via student financial aid, intergovernmental transfers, and institutional research grants. Of course, the appropriate extent of federal involvement in higher education is an unresolved issue that concerns issues of ideology, equity, and efficiency.

Another important unanswered question closely related to the current study is how state and federal governments can best increase college graduation rates among young people. Over the past two decades several states have adopted state merit-based financial aid programs attempting to boost their higher education. Unfortunately, these merit aid programs have not significantly increased college completion rates (Fitzpatrick and Jones 2012; Sjoquist and Winters 2015). Additional need-based student financial aid for young people from low- and moderate-income households may have some potential to increase college completion rates, but some observers suggest that federal Pell Grants and student loans are already sufficiently generous that financial need may not be a major obstacle to college success for these students.

Other obstacles to college success may be especially pertinent. According to the 2012 ACS, more than two-thirds of young adults have attended at least some college by age 25. However, less than half of those with some college have completed a bachelor's degree or higher, even by age 30. Getting people in the doors of the higher education system does not appear to be the major problem—the problem is that so many college attendees drop out without completing a college degree, largely because of inadequate student preparation and decreases in institutional resources per student (Bound, Lovenheim, and Turner 2010). Thus, policymakers interested in growing the stock of college graduates may be well served by increasing public investments in primary, secondary, and higher education that are targeted to helping students obtain a high-quality education and succeed in college.

Other important questions related to the production and stock of college graduates remain unanswered and should be further considered in future research. One largely unexplored issue is whether the type of education matters for graduate migration. Higher education generally imparts specialized skills that vary considerably with the major field of study. These skills are much more valuable in some areas than in others, and graduates are likely to relocate toward areas that especially reward the specific skills in which they have invested. This creates questions about which major fields of study states should offer. Should they focus on ones currently in high demand in their state or are there benefits to investing in others less in demand? Additional questions relate to differences in migration behavior between other groups, including first-generation graduates vs. those with college-educated parents, graduates with and without considerable amounts of student debt, and graduates educated in their home state vs. those educated outside their home state including foreign-born graduates educated in the United States.

CONCLUSION

College graduates are very important to state economies, but they are also especially mobile and there is a concern that out-migration may significantly reduce a state's return on public investments in college graduates. This paper examines the relationship between the production of college graduates from a state and the stock of college graduates residing in the state years later using microdata from the decennial census and ACS. The stock of college graduates in a state is measured by the percentage of the state's residents of a given age with a bachelor's degree or higher. The production of college graduates from a state is measured by the percentage of persons of a given age born in the state who have earned at least a bachelor's degree, regardless of where the degree was earned. This production measure relates to broad goals of increasing college graduation rates among a state's young people.

Cross-sectional OLS estimates suggest that the bivariate relationship between the production and stock of college graduates has increased in recent years and is nearly proportional, especially for younger persons. The preferred estimates, however, utilize state fixed effects so that identification comes from across cohorts within states. Potential endogeneity is addressed by instrumenting for college graduate production using lagged maternal education levels; the analysis also controls for several time-varying state characteristics. The preferred IV results yield a point estimate for the production-stock relationship of 0.52. However, the production-stock relationship is found to decrease with age. The magnitude of the positive production-stock relationship estimated in this study supports the notion that states may sufficiently benefit from public investments in education to warrant the large investments that they make. However, educational investment benefits do spill over state boundaries and federal investments in education are also potentially justifiable.

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Table 1 College Shares by State of Birth and State of Residence, 2012 ACS

	State of birth		State of residence	
State	Rank	College share	Rank	College share
Alabama	47	24.7	43	24.9
Alaska	37	25.9	27	28.7
Arizona	42	25.2	35	27.3
Arkansas	43	25.2	47	22.3
California	29	29.7	17	31.5
Colorado	14	33.9	5	38.5
Connecticut	1	41.0	2	39.7
Delaware	17	33.1	16	31.6
Florida	34	26.9	34	27.4
Georgia	44	25.1	23	29.8
Hawaii	16	33.1	18	31.4
Idaho	28	29.7	39	25.9
Illinois	12	34.3	11	34.2
Indiana	32	28.3	42	25.0
Iowa	9	34.9	24	29.6
Kansas	15	33.5	15	32.0
Kentucky	48	24.5	45	23.5
Louisiana	45	25.0	46	23.0
Maine	36	26.6	30	28.3
Maryland	19	32.4	4	38.8
Massachusetts	2	40.8	1	42.9
Michigan	25	30.1	31	28.0
Minnesota	8	35.6	10	35.4
Mississippi	49	24.3	49	21.1
Missouri	24	30.3	29	28.3
Montana	20	32.3	28	28.4
Nebraska	5	36.4	13	32.7
Nevada	39	25.5	48	22.1
New Hampshire	10	34.4	7	36.7
New Jersey	4	39.0	3	39.3
New Mexico	41	25.3	40	25.4
New York	3	39.2	8	36.2
North Carolina	38	25.5	26	29.0
North Dakota	7	36.0	20	31.1
Ohio	27	29.8	36	27.3
Oklahoma	31	28.7	44	24.1
Oregon	33	27.8	22	30.6
Pennsylvania	13	34.1	19	31.4
Rhode Island	6	36.0	12	33.0
South Carolina	46	24.9	37	26.3
South Dakota	18	32.7	32	27.8
Tennessee	40	25.4	38	26.3
Texas	35	26.8	33	27.5
Utah	21	32.0	21	30.7
Vermont	22	30.8	9	36.2
Virginia	30	29.6	6	37.9
Washington	23	30.5	14	32.1
West Virginia	50	23.6	50	20.0
Wisconsin	11	34.4	25	29.4
Wyoming	26	29.9	41	25.1

NOTE: The college shares report the percentage of persons aged 25–59 who have at least a bachelor’s degree.

Table 2 Cross-Sectional OLS Effects of Graduate Production on the Stock of College Graduates

Ages	1960	1970	1980	1990	2000	2006	2012
25–59	0.493	0.529	0.559	0.641	0.680	0.761	0.847
	(0.042)***	(0.058)***	(0.072)***	(0.089)***	(0.100)***	(0.088)***	(0.083)***
25–29	0.587	0.573	0.598	0.809	0.883	0.871	0.965
	(0.050)***	(0.057)***	(0.061)***	(0.092)***	(0.072)***	(0.073)***	(0.086)***
30–34	0.545	0.549	0.567	0.780	0.813	0.926	0.989
	(0.046)***	(0.063)***	(0.070)***	(0.087)***	(0.087)***	(0.069)***	(0.082)***
35–39	0.485	0.562	0.593	0.609	0.722	0.818	0.816
	(0.050)***	(0.062)***	(0.086)***	(0.094)***	(0.112)***	(0.092)***	(0.078)***
40–44	0.510	0.495	0.597	0.564	0.652	0.753	0.755
	(0.047)***	(0.063)***	(0.082)***	(0.096)***	(0.129)***	(0.107)***	(0.112)***
45–49	0.471	0.478	0.553	0.593	0.569	0.705	0.690
	(0.060)***	(0.065)***	(0.078)***	(0.093)***	(0.113)***	(0.133)***	(0.117)***
50–54	0.483	0.506	0.524	0.545	0.546	0.595	0.710
	(0.049)***	(0.067)***	(0.070)***	(0.086)***	(0.098)***	(0.114)***	(0.120)***
55–59	0.342	0.434	0.485	0.559	0.564	0.554	0.606
	(0.064)***	(0.061)***	(0.082)***	(0.086)***	(0.098)***	(0.091)***	(0.125)***

NOTE: ***Statistically significantly different from zero at the 1% level. Each 2×1 cell reports results for a separate OLS regression with 50 observations, one for each state. The dependent variable is the state of residence college share for the particular age group, and the explanatory variable is the state of birth college share for the same age group. The college share for each refers to the percentage of persons who have earned at least a bachelor's degree. Standard errors in parentheses are heteroskedasticity-robust.

Table 3 OLS Results Explaining the Stock of College Graduates For Cohorts Born 1963–1987

	(1)	(2)	(3)	(4)
Birth state college share	0.827	0.815	0.521	0.477
	(0.051)***	(0.059)***	(0.030)***	(0.025)***
Age dummies	No	Yes	Yes	Yes
Year dummies	No	Yes	Yes	Yes
Year of birth dummies	No	Yes	Yes	Yes
State dummies	No	No	Yes	Yes
Cohort sex & race/ethnicity	No	No	No	Yes
Other cohort controls	No	No	No	Yes
Number of age-year-state cohorts	7,700	7,700	7,700	7,700

NOTE: ***Statistically significantly different from zero at the 1% level of significance. The dependent variable is the state of residence college share by age and survey year. The college share, sex, and race/ethnicity explanatory variables are measured by birth state, age, and survey year. Other cohort controls include the unemployment rate, college-high school log wage gap, log cohort size, log median household income, and a state merit-aid program dummy measured based on state of birth at age 18. Standard errors are clustered by state.

Table 4 2SLS Results Explaining the Stock of College Graduates Using the Maternal Education Instrument

	(1)	(2)	(3)	(4)
First-stage results				
% Mom with bachelor's or higher	0.645	1.651	0.643	0.407
	(0.084)***	(0.195)***	(0.081)***	(0.043)***
Excluded instrument F-statistic	58.77	71.42	63.48	90.90
2SLS results				
Birth state college share	1.033	1.107	0.870	0.522
	(0.084)***	(0.085)***	(0.204)***	(0.221)**
Age dummies	No	Yes	Yes	Yes
Year dummies	No	Yes	Yes	Yes
Year of birth dummies	No	Yes	Yes	Yes
State dummies	No	No	Yes	Yes
Cohort sex & race/ethnicity	No	No	No	Yes
Other cohort controls	No	No	No	Yes
Number of age-year-state cohorts	7,700	7,700	7,700	7,700

NOTE: **Statistically significantly different from zero at the 5% level; ***significant at the 1% level. The dependent variable is the state of residence college share by age and survey year. The college share, sex, and race/ethnicity explanatory variables are measured by birth state, age, and survey year. Other cohort controls include the unemployment rate, college-high school log wage gap, log cohort size, log median household income, and a state merit-aid program dummy measured based on state of birth at age 18. Standard errors are clustered by state.

Table 5 Separate 2SLS Results for Ages 25–35 and 36–49 Using the Maternal Education Instrument

	(1) Ages 25–35	(2) Ages 36–49
First-stage results		
% Mom with bachelor's or higher	0.296	0.325
	(0.056)***	(0.081)***
Excluded instrument F-statistic	27.88	16.15
2SLS Results		
Birth state college share	0.750	0.366
	(0.258)***	(0.165)**
Age dummies	Yes	Yes
Year dummies	Yes	Yes
Year of birth dummies	Yes	Yes
State dummies	Yes	Yes
Cohort sex & race/ethnicity	Yes	Yes
Other cohort controls	Yes	Yes
Number of age-year-state cohorts	3,850	3,850

NOTE: **Statistically significantly different from zero at the 5% level; ***significant at the 1% level. The dependent variable is the state of residence college share by age and survey year. The college share, sex, and race/ethnicity explanatory variables are measured by birth state, age, and survey year. Other cohort controls include the unemployment rate, college-high school log wage gap, log cohort size, log median household income, and a state merit-aid program dummy measured based on state of birth at age 18. Standard errors are clustered by state.

Appendix

Table A.1 2SLS Results Using One-Year Lagged College Share in Birth State as an Instrument

	(1)	(2)	(3)	(4)
First-stage results				
Birth state college share in $t - 1$	0.839	0.834	0.166	0.087
	(0.026)***	(0.030)***	(0.035)***	(0.016)***
Excluded instrument F-statistic	1024.75	756.58	22.22	29.59
2SLS results				
Birth state college share	0.893	0.884	0.860	0.638
	(0.056)***	(0.065)***	(0.134)***	(0.211)***
Age dummies	No	Yes	Yes	Yes
Year dummies	No	Yes	Yes	Yes
Year of birth dummies	No	Yes	Yes	Yes
State dummies	No	No	Yes	Yes
Cohort sex & race/ethnicity	No	No	No	Yes
Other cohort controls	No	No	No	Yes
Number of age-year-state cohorts	6,750	6,750	6,750	6,750

NOTE: ***Statistically significantly different from zero at the 1% level. The dependent variable is the state of residence college share by age and survey year. The college share, sex, and race/ethnicity explanatory variables are measured by birth state, age, and survey year. Other cohort controls include the unemployment rate, college-high school log wage gap, log cohort size, log median household income, and a state merit-aid program dummy measured based on state of birth at age 18. Standard errors are clustered by state.

Table A.2 2SLS Results Explaining the Stock of College Graduates Using Both Instruments

	(1)	(2)	(3)	(4)
First-stage results				
Birth state college share in $t-1$	0.780	0.685	0.091	0.060
	(0.026)***	(0.034)***	(0.015)***	(0.014)***
% Mom with bachelor's or higher	0.213	0.510	0.569	0.376
	(0.015)***	(0.080)***	(0.072)***	(0.041)***
Excluded instrument F-statistic	1185.80	544.40	42.85	46.07
2SLS results				
Birth state college share	0.906	0.930	0.873	0.557
	(0.055)***	(0.063)***	(0.190)***	(0.220)**
Hansen J-statistic p-value	0.108	0.001	0.925	0.608
Age dummies	No	Yes	Yes	Yes
Year dummies	No	Yes	Yes	Yes
Year of birth dummies	No	Yes	Yes	Yes
State dummies	No	No	Yes	Yes
Cohort sex & race/ethnicity	No	No	No	Yes
Other cohort controls	No	No	No	Yes
Number of age-year-state cohorts	6,750	6,750	6,750	6,750

NOTE: **Statistically significantly different from zero at the 5% level; ***statistically significantly different from zero at the 1% level. The dependent variable is the state of residence college share by age and survey year. The college share, sex, and race/ethnicity explanatory variables are measured by birth state, age, and survey year. Other cohort controls include the unemployment rate, college-high school log wage gap, log cohort size, log median household income, and a state merit-aid program dummy measured based on state of birth at age 18. Standard errors are clustered by state.

Table A.3 Separate 2SLS Results for Ages 25–35 and 36-49 Using One-Year Instrument and Both Instruments

	(1) Ages 25–35	(2) Ages 25–35	(3) Ages 36–49	(4) Ages 36–49
First-stage results				
Birth state college share in $t-1$	0.065	0.053	0.027	0.018
	(0.020)***	(0.019)***	(0.019)	(0.018)
% Mom with bachelor's or higher		0.239		0.315
		(0.060)***		(0.076)***
Excluded instrument F-statistic	10.34	11.73	2.15	9.14
2SLS results				
Birth state college share	1.066	0.887	1.458	0.361
	(0.357)***	(0.270)***	(0.767)*	(0.179)**
Hansen overidentification p-value		0.385		0.037
Age dummies	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Year of birth dummies	Yes	Yes	Yes	Yes
State dummies	Yes	Yes	Yes	Yes
Cohort sex & race/ethnicity	Yes	Yes	Yes	Yes
Other cohort controls	Yes	Yes	Yes	Yes
Number of age-year-state cohorts	3,300	3,300	3,450	3,450

NOTE: **Statistically significantly different from zero at the 5% level; ***statistically significantly different from zero at the 1% level. The dependent variable is the state of residence college share by age and survey year. The college share, sex, and race/ethnicity explanatory variables are measured by birth state, age, and survey year. Other cohort controls include the unemployment rate, college-high school log wage gap, log cohort size, log median household income, and a state merit-aid program dummy measured based on state of birth at age 18. Standard errors are clustered by state.